Claims

1. A method of operating a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, the method comprising:

firing a plurality of burners to generate combustion products, and directing jets of the combustion products into the shaft in a bottom region of the shaft; and

directing a jet of hot gas into the shaft in an upper region of the shaft in a non-radial direction, whereby the non-radial jet of hot gas can induce a swirl to disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

2. A method as defined in claim 1 wherein the non-radial direction is inclined downward from horizontal.

3. A method as defined in claim 1 wherein the non-radial jet of hot gas is one of a plurality of jets of hot gas that are directed into the shaft in the upper region of the shaft in non-radial directions, and the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

4. A method as defined in claim 1 wherein the non-radial jet of hot gas is an upper jet of combustion products generated by an upper burner.

5. A method as defined in claim 4 wherein each of the plurality of burners that is fired into the bottom region of the shaft is fired with a first individual heat input, and the upper burner is fired into the upper region of the shaft with a second, lower individual heat input.

6. A method as defined in claim 4 wherein the upper burner is one of a plurality of upper burners that are fired into the shaft in the upper region of the shaft in non-radial directions.

7. A method as defined in claim 6 wherein the in non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

8. A method as defined in claim 1 wherein the non-radial jet of hot gas comprises an upper jet of combustion products generated by an upper burner, the upper burner is fired into a plenum that communicates the upper burner with the shaft, and multiple upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft.

9. A method as defined in claim 8 wherein the multiple upper jets of combustion products are directed into the shaft in non-radial directions.

10. A method as defined in claim 9 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

11. A method of retrofitting a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to generate combustion products and to direct jets of the combustion products into the shaft in a bottom region of the shaft, the method comprising:

installing a device that is operative to direct a jet of hot gas into the shaft in an upper region of the shaft in a non-radial direction, whereby the non-radial jet of hot gas can induce a swirl to disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

12. A method as defined in claim 11 wherein the non-radial direction is inclined downward from horizontal.

13. A method as defined in claim 11 further comprising the step of installing an additional device such that the installed devices are operative to direct jets of hot gas into the shaft in the

upper region of the shaft in non-radial directions that together extend in a common direction circumferentially around the inside of the shaft.

14. A method as defined in claim 11 wherein the device is an upper burner, and the non-radial jet of hot gas comprises an upper jet of combustion products generated by the upper burner.

15. A method as defined in claim 14 wherein each of the plurality of burners that is operative to fire into the bottom region of the shaft is operative to fire with a first individual heat input, and the upper burner is operative to fire into the upper region of the shaft with a second, lower individual heat input.

16. A method as defined in claim 15 wherein the plurality of burners that are operative to fire into the bottom region of the shaft are premix burners and the upper burner is a nozzle mix burner.

17. A method as defined in claim 15 wherein the furnace has a control system that is operative to fire each of the plurality of burners with the first individual heat input, and further comprising the step of rendering the control system operative to fire the upper burner with the second, lower individual heat input.

18. A method as defined in claim 11 wherein the device is an upper burner and the non-radial jet of hot gas comprises an upper jet of combustion products generated by the upper burner, and further comprising the step of installing a plenum that communicates the upper burner with the shaft such that the upper burner is operative to fire into the plenum, and multiple upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft, when the upper burner is fired.

19. A method as defined in claim 18 wherein the plenum is installed such that the plurality of upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft in non-radial directions.

20. A method as defined in claim 19 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

21. An apparatus for use in a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to fire into the shaft in a bottom region of the shaft, the apparatus comprising:

a device that is operative to direct a jet of hot gas into the shaft in an upper region of the shaft in a non-radial direction, whereby the non-radial jet of hot gas can induce a swirl to disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

22. An apparatus as defined in claim 21 wherein the non-radial direction is inclined downward from horizontal.

23. An apparatus as defined in claim 21 wherein the device is one of a plurality of devices that are operative to direct jets of hot gas into the shaft in the upper region of the shaft in non-radial directions that together extend in a common direction circumferentially around the inside of the shaft.

24. An apparatus as defined in claim 21 wherein the device is an upper burner, and the non-radial jet of hot gas comprises an upper jet of combustion products generated by the upper burner.

25. An apparatus as defined in claim 24 wherein the upper burner is one of a plurality of upper burners that are operative to fire into the shaft in the upper region of the shaft in non-radial directions.

26. An apparatus as defined in claim 25 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

27. An apparatus as defined in claim 24 wherein the plurality of burners that are operative to fire into the shaft in the bottom region of the shaft are premix burners and the upper burner is a nozzle mix burner.

28. An apparatus as defined in claim 24 wherein each of the plurality of burners that are operative to fire into the bottom region of the shaft is operative to fire with a first individual heat input, and the upper burner is operative to fire with a second, lower individual heat input.

29. An apparatus as defined in claim 28 further comprising a control system that is operative to fire each of the plurality of burners with the first individual heat input, and to fire the upper burner with the second, lower individual heat input.

30. An apparatus as defined in claim 21 wherein the device is an upper burner and the non-radial jet of hot gas comprises an upper jet of combustion products generated by the upper burner, and further comprising a plenum that communicates the upper burner with the shaft such that the upper burner is operative to fire into the plenum, and multiple upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft, when the upper burner is fired.

31. An apparatus as defined in claim 30 wherein the plenum is configured to direct the upper jets of combustion products into the upper region of the shaft in non-radial directions.

32. An apparatus as defined in claim 31 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

33. A method of operating a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, the method comprising:

firing a plurality of burners to generate combustion products, and directing jets of the combustion products into the shaft at a plurality of vertically spaced levels including an uppermost level, with a jet of combustion products at the uppermost level being directed into the shaft in a non-radial direction, whereby the non-radial jet of combustion products can induce a swirl to disperse a concentrated channel of combustion products rising through a void in unmelted portions of a load of metal pieces in the shaft.

34. A method as defined in claim 33 wherein the non-radial jet of combustion products is directed into the shaft in a direction inclined downward from horizontal.

35. A method as defined in claim 33 wherein the non-radial jet of combustion products is one of a plurality of jets of combustion products at the uppermost level that are directed into the shaft in non-radial directions.

36. A method as defined in claim 35 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

37. A method of retrofitting a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to generate combustion products and to direct jets of the combustion products into the shaft at a plurality of vertically spaced levels, the method comprising:

installing a burner that is operative to direct a jet of combustion products into the shaft at an uppermost level in a non-radial direction, whereby the non-radial jet of combustion products can induce a swirl to disperse a concentrated channel of combustion products rising through a void in unmelted portions of a load of metal pieces in the shaft.

38. A method as defined in claim 37 wherein the non-radial direction is inclined downward from horizontal.

39. A method as defined in claim 37 further comprising the step of installing an additional burner such that the installed burners are operative to direct jets of combustion products into the shaft at the uppermost level in non-radial directions.

40. A method as defined in claim 39 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

41. An apparatus for use in a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to fire into the shaft at a plurality of vertically spaced levels, the apparatus comprising:

a burner that is operative to direct a jet of combustion products into the shaft at an uppermost level in a non-radial direction, whereby the non-radial jet of combustion products can induce a swirl to disperse a concentrated channel of combustion products rising through a void in unmelted portions of a load of metal pieces in the shaft.

42. An apparatus as defined in claim 41 wherein the non-radial direction is inclined downward from horizontal.

43. An apparatus as defined in claim 41 wherein the burner is one of a plurality of burners that are operative to direct jets of combustion products into the shaft at the uppermost level in non-radial directions.

44. An apparatus as defined in claim 43 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

45. A method of operating a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, the method comprising:

firing each of a plurality of primary burners into the shaft in a bottom region of the shaft with a first individual heat input; and

simultaneously firing a secondary burner into the shaft in an upper region of the shaft with a second, lower individual heat input, whereby the secondary burner can disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

46. A method as defined in claim 45 wherein the secondary burner is fired into the shaft in a direction inclined downward from horizontal.

47. A method as defined in claim 45 wherein the secondary burner is one of a plurality of secondary burners that are fired into the shaft in the upper region of the shaft with the second, lower individual heat input.

48. A method as defined in claim 45 wherein the secondary burner fires a jet of secondary combustion products into a plenum that communicates the secondary burner with the shaft, and multiple jets of secondary combustion products are directed from the plenum into the shaft in the upper region of the shaft.

49. A method of retrofitting a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to fire into the shaft in a bottom region of the shaft, with each of that plurality of burners being operative to fire with a first individual heat input, the method comprising:

installing an upper burner that is operative to fire into the shaft in an upper region of the shaft with a second, lower individual heat input, whereby the upper burner can disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

50. A method as defined in claim 49 wherein the upper burner is operative to fire into the shaft in the upper region of the shaft in a direction inclined downward from horizontal.

51. A method as defined in claim 49 wherein the plurality of burners that are operative to fire into the shaft in the bottom region of the shaft are premix burners, and the upper burner is a nozzle mix burner.

52. A method as defined in claim 49 wherein wherein the furnace has a control system that is operative to fire each of the plurality of burners with the first individual heat input, and further comprising the step of rendering the control system operative to fire the upper burner with the second, lower individual heat input.

53. A method as defined in claim 49 further comprising the additional steps of installing additional upper burners, each of which is operative to fire into the shaft in the upper region of the shaft with the second, lower individual heat input.

54. A method as defined in claim 49 further comprising the step of installing a plenum that communicates the upper burner with the shaft such that the upper burner is operative to fire an

upper jet of combustion products into the plenum, and multiple upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft, when the upper burner is fired.

55. A method as defined in claim 49 wherein the plenum is installed such that the upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft in non-radial directions when the upper burner is fired.

56. A method as defined in claim 55 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.

57. An apparatus for use in a vertical shaft melting furnace having a shaft configured to receive metal pieces that together comprise a load that may have a vertically extending void, and further having a plurality of burners that are operative to fire into the shaft in a bottom region of the shaft, with each of the plurality of burners being operative to fire with a first individual heat input, the apparatus comprising:

an upper burner that is operative to fire into the shaft in an upper region of the shaft with a second, lower individual heat input, whereby the upper burner can disperse a concentrated channel of combustion products rising from the bottom region to the upper region through a void in unmelted portions of a load of metal pieces in the shaft.

58. An apparatus as defined in claim 57 wherein the upper burner is operative to fire into the shaft in the upper region of the shaft in a direction inclined downward from horizontal.

59. An apparatus as defined in claim 57 wherein the plurality of burners that are operative to fire into the bottom region of the shaft are premix burners, and the upper burner is a nozzle mix burner.

60. An apparatus as defined in claim 57 further comprising a control system that is operative to fire each of the plurality of burners with the first individual heat input, and to fire the upper burner with the second, lower individual heat input.

61. An apparatus as defined in claim 57 wherein the upper burner is one of a plurality of upper burners, each of which is operative to fire into the shaft in the upper region of the shaft with the second, lower individual heat input.

62. An apparatus as defined in claim 57 further comprising a plenum that communicates the upper burner with the shaft such that the upper burner is operative to fire an upper jet of combustion products into the plenum, and multiple upper jets of combustion products are directed from the plenum into the shaft in the upper region of the shaft, when the upper burner is fired.

63. An apparatus as defined in claim 62 wherein the plenum is configured to direct the upper jets of combustion products into the shaft in the upper region of the shaft in non-radial directions.

64. An apparatus as defined in claim 63 wherein the non-radial directions together extend in a common direction circumferentially around the inside of the shaft.